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(12) # EUROPEAN PATENT APPLICATION

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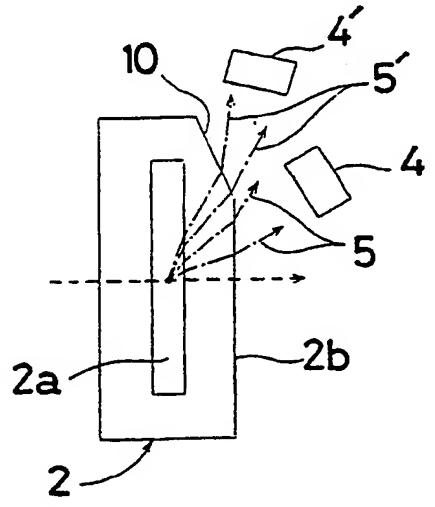
(54) **Apparatus for measuring the distribution of the size of diffraction-scattering type particles.**

(57) The invention relates to an apparatus for measuring a distribution of the size of diffraction-scattering type particles (6), in which a liquid containing said particles (6) and flowing through an inside of a sample cell (2) having a square-sectioned external form is irradiated with a coherent light (1) to monitor an intensity pattern of a light diffracted-scattered by said particles (6) by means of an optical detector, whereby measuring said distribution of the particle size.
At least one part (10) of an outer surface (2b) on the radiating side of the sample cell (2) is bereled.

Fig. 2



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Field of the Invention

The present invention relates to an apparatus as claimed in the preamble of claim 1 for measuring a distribution of the size of diffraction-scattering type particles.

Description of the Prior Art

Fig. 4 shows main parts in a conventional general apparatus for measuring a distribution of the size of diffraction-scattering type particles. Referring to Fig. 4, reference numeral 1 designates a laser beam emitted from a laser device (not shown), reference numeral 2' designates a square cylindrical sample cell having a square sectioned external form and an internal space 2a' which is continuously supplied with a sample liquid from an ultrasonic diffusion bath (not shown) by means of a circulating pump (not shown), reference numeral 3 designates a condenser lens for collecting a light, which has transmitted through said sample cell 2', and a light, which has been scattered (diffracted) by particles contained in said sample liquid within the sample cell, and reference numeral 4 designates a detector formed of, for example, a silicon photodiode for detecting a light from said condenser lens 3.

In the above described apparatus for measuring a distribution of particle size, upon applying said laser beam 1 to the sample cell 2' under the condition that said internal space 2a' of the sample cell 2' is continuously supplied with the sample liquid, a part of the laser beam 1 is applied to said particles in the sample liquid within the sample cell 2' to be turned into a scattered (diffracted) light 5, whereby arriving at said detector 4 through the condenser lens 3.

However, in the apparatus for measuring a distribution of particle size having the above described construction, as shown in Fig. 5(A), (B), in the case where an angle ϕ_1 between said light 5 scattered by the particles 6 and an outer surface 2b' of the sample cell 2 is large, that is a scattering angle θ_1 from the particles 6 is small (for example θ_1 < about 50° in the case where a dispersion medium is water), the scattered light 5 arrives at the detector 4 through the sample cell 2'. But in the case where an angle ϕ_2 between the scattered light 5' and said outer surface 2b' of the sample cell 2 is small, that is a scattering angle θ_2 from the particles 6 is large ($\theta_1 \geq$ about 50° in the case where a dispersion medium is water similarly), the scattered light 5' is totally reflected by the outer surface 2b' of the sample cell 2 without transmitting through the sample cell 2'. In general, the smaller the particle size is, the larger the scattering angle θ is, so that, with the conventional apparatus for measuring a distribution of the size of diffraction-scattering type particles, sizes of particles having reduced diameters are difficult to measure and thus the measurement of a distribution of particle size over a wide range is impossible.

SUMMARY OF THE INVENTION

The present invention has been achieved paying attention to the above described matters and it is an object thereof to provide an apparatus having a relatively simple construction for measuring a distribution of the size of diffraction-scattering type particles capable of measuring also with high accuracy a size of particles having a reduced diameter in order to obtain a distribution of the particle size over a wide range.

In order to achieve the above described object, at least one part of an outer surface on the radiating side of said sample cell is beveled in order to avoid total reflection for such diffracted-scattered light on said radiating side having a large diffraction scatter ing angle.

According to the above described characteristic construction, the angle between the scattered light and the outer surface of the sample cell can be substantially increased by beveling a part of the outer surface of the sample cell, so that the scattered light, which has been unable to pass through the outer surface of sample cell on account of the formally reduced angle between the scattered light and the outer surface of the sample cell, can now be measured and thus the distribution of particle size of the particles having small diameters to large diameters can be measured over a wide range.

BRIEF DESCRIPTION OF THE DRAWINGS

One preferred embodiment of the present invention is shown in Fig. 1(A), (B) and Fig. 2, in which

Fig. 1(A) is a block diagram showing main parts of an apparatus for measuring a distribution of the size of diffraction-scattering type particles;

Fig. 1(B) is a whole perspective view showing a sample cell of said apparatus; and

Fig. 2 is a drawing for describing an operation of the sample cell shown in Fig. 1(B).

Fig. 3 shows another preferred embodiment of the present invention and an operation of a sample cell.

Fig. 4 and 5 is a drawing for describing the prior art, respectively.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Preferred embodiments of the present invention will be described below with reference to the drawings.

One preferred embodiment of the present invention is shown in Figs. 1(A), (B) and Fig. 2. Referring to Fig. 1(A), reference numeral 7 designates a laser device for emitting a laser beam 1, reference numeral 8 designates a beam expander for suitably magnifying said laser beam, reference numeral 2 designates a sample cell communicatedly connected with an ultrasonic dispersion bath (not shown) through a piping 9 and continuously supplied with a sample liquid by means of a circulating pump (not shown). and reference numerals 4, 4' designates detectors each formed of, for example, a silicon photodiode for detecting a light which has passed through said sample cell 2 and has been diffracted-scattered by the particles in the sample.

The sample cell 2 according to the present invention is greatly different from the conventional cell 2' in that the sample cell 2 is provided with a beveled portion 10 formed on an outer surface 2b on the radiating side thereof, as shown in Fig. 1(B).

A construction and an operation of the sample cell 2 are below described with reference to also Fig. 2. The sample cell 2 is made of a material, such as glass (for example quartz and BK-7 glass), superior in light-transmissivity and an external form and an internal space 2a of a light-transmissive portion have a square section.

Said beveled portion 10 is formed in one edge portion of said outer surface 2b on the radiating side (light output side) of the sample cell 2 to substantially increase an angle between a scattered light h' and the beveled portion 10 in order to take said scattered light 5' out of the sample cell 2, whereby detecting the scattered light 5' by means of said detector 4', as above described. In addition, a scattered light 5 having a small scattering angle, which has passed through the outer surface 2b of the sample cell 2 which is not beveled, is detected by means of said separately provided detector 4. Alternatively, both said scattered light 5 and the scattered light 5' may be detected by means of only one detector 4 by providing a collecting lens behind the sample cell 2.

Fig. 3 shows another preferred embodiment of the present invention. A sample cell 2 is provided with a beveled portion 11 formed in an edge portion opposite to that in the above described preferred embodiment of an outer surface 2b on the radiating side thereof and a detector 4' is provided in said beveled portion 11 to detect a scattered light 5'. In addition. a scattered light 5 is detected by means of a detector 4 provided in the same manner as in the above described preferred embodiment.

Said angles of said beveled portions 10, 11 described in the present preferred embodiments are differently set depending upon the material and size of the sample cell, the refractive index of the dispersion medium and the like, so that they may be suitably and optionally selected. In addition, the beveled portion is not limited by the flat surface as in the above described preferred embodiment, that is it may also be a curved surface.

As above described, according to the present invention, the distribution of the size of particles having small diameters to large diameters can be measured over a wide range by such the simple device because of the beveled portion in a part of the outer surface of the sample cell.

Claims

1. An apparatus for measuring a distribution of the size of diffraction-scattering type particles (6), in which a liquid containing said particles (6) and flowing through an inside of a sample cell (2) having a square-sectioned external form is irradiated with a coherent light (1) to monitor an intensity pattern of a light diffracted-scattered by said particles (6) by means of an optical detector, whereby measuring said distribution of the particle size, **characterized in that** at lest one part (10, 11) of an outer surface (2b) on the radiating side of said sample cell (2) is beveled in order to avoid total reflection for such diffracted-scattered light (5') on said radiating side having a large diffraction-scattering angle.

2. The apparatus as claimed in claim 1, **characterized in that** the beveled part (10, 11) of the sample cell (2) has a flat surface.

3. The apparatus as claimed in claim 1, **characterized in that** the beveled part (10, 11) of the sample cell (2) has a curved surface.

4. The apparatus as claimed in one of the claims 1 to 3, **characterized in that** separate detectors (4, 4') are provided for detecting a light (5, 5') diffracted-scattered under a small/large diffraction-scattering angle.

5. The apparatus as claimed in one of the claims 1 to 3, **characterized in that** the light (5, 5') diffracted-scattered under small and large diffraction-scattering angles is detected by means of merely one detector, and in that a collecting lens is provided between said detector and the sample cell (2).

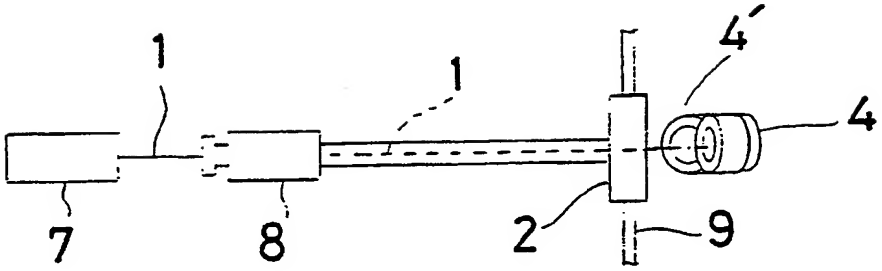
6. The apparatus as claimed in claim 4, **characterized in that** the detectors (4, 4') for

detecting the diffracted-scattered light (5, 5') having small/large diffraction-scattering angles are positioned on the same side of the coherent input light beam (1).

7. The apparatus as claimed in claim 4, **characterized in that** the detectors (4, 4') for detecting the diffracted-scattered light (5, 5') having small/ large diffraction-scattering angles are positioned on different sides of the coherent input light beam (1).

Fig. 1

(A)



(B)

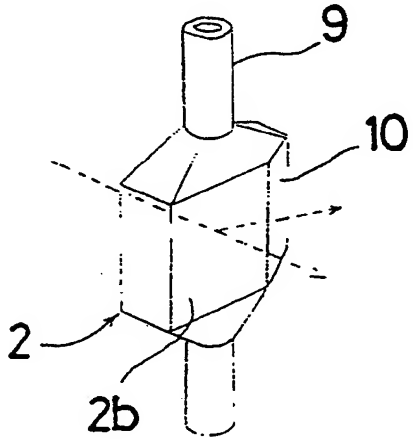


Fig. 2

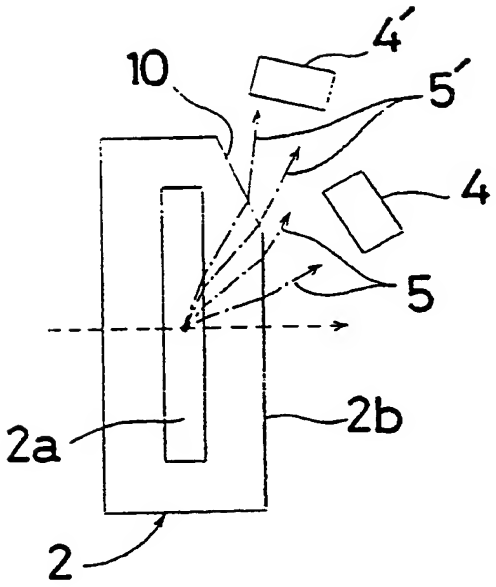


Fig. 3

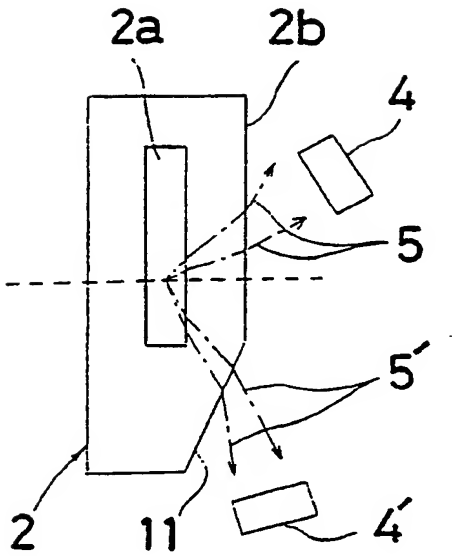


Fig. 4

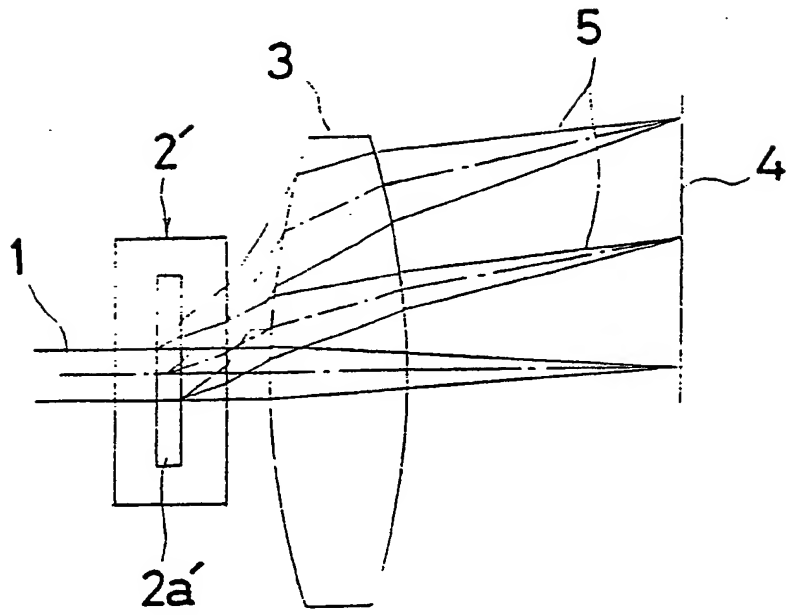
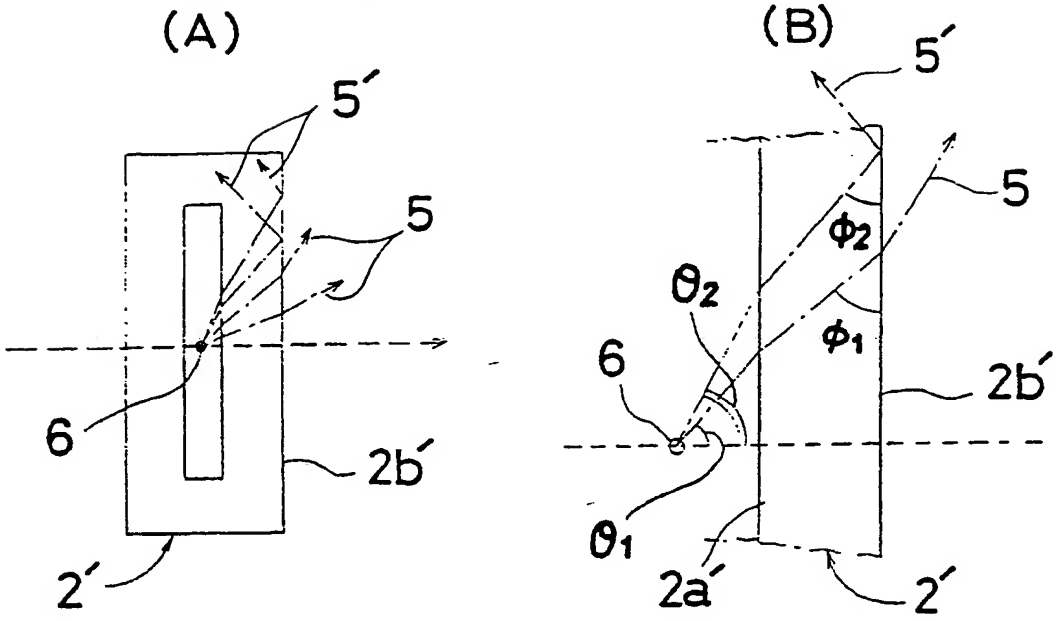


Fig. 5 PRIOR ART



European Patent Office

EUROPEAN SEARCH REPORT

Application Number

EP 91 10 4060

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.5)
Y	US-A-4 906 094 (K. ASHIDA) * column 1; column 28, lines 27-41 *	1,2,4-7	G 01 N 15/02
Y	PATENT ABSTRACTS OF JAPAN vol 12, no. 8 (P-654)(2855), 12 January 1988; & JP - A - 62168033 (CANON INC.) 24.07.1987	1,2,4-7	
A	GB-A-2 095 827 (CENTRE SCIENTIFIQUE ET TECHNIQUE DE L'INDUSTRIE TEXTILE BELGE) * abstract; figure 2 *	1	
A	WO-A-8 701 451 (COMMONWEALTH SCIENTIFIC & INDUSTRIAL RESEARCH ORGANIZATION) * page 3, line 16 - page 5, line 10; figure 1 *	1	
A	EP-A-0 029 662 (ORTHO DIAGNOSTICS INC.) * figure 1 *	1	
A	REVIEW OF SCIENTIFIC INSTRUMENTS vol. 55, no. 9, September 1984, pages 1375-1400, New York, NY, US; J.A. STEINKAMP: "Flow cytometry" * figure 5 *	1	

TECHNICAL FIELDS SEARCHED (Int. Cl.5)

G 01 N

The present search report has been drawn up for all claims

Place of search	Date of completion of search	Examiner
Berlin	27 June 91	BRISON O.P.

CATEGORY OF CITED DOCUMENTS

X: particularly relevant if taken alone
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